Coastal Science Assistantship Program Application

Names: Kehui Xu, Victor H. Rivera-Monroy

Sediment-Plant Interaction Studies to Benefit Coastal Protection and Restoration of Louisiana

SUMMARY

In 2012 the Coastal Protect & Restoration Authority (CPRA) issued Louisiana's Comprehensive Master Plan for a Sustainable Coast. One of the restoration tools promoted by CPRA is the diversion of sediment-laden water from the Mississippi and Atchafalaya Rivers into adjacent basins to build new land. In the next 50 years, billions of dollars will be spent on many diversion projects along the Louisiana coast. Several large diversions, such as these at Breton Sound and Barataria Bay, are in a planning phase and to be constructed in the next a few decades. Site selections of multiple large diversions will rely heavily on the predictions of numerical models, which require extensive inputs of parameters measured in the field.

During the past several decades there have been numerous wetland and deltaic studies in Louisiana coast. A number of biogeochemists have been studying nutrient cycles and plant growth/decay on the wetlands; many geologists focused on large scale morphological evolution and geological framework of deltaic environments. However, not many biogeochemists and geologists worked **together** to study the sediment-plant interaction, a challenging yet very exciting topic. The success of many diversion projects depends on the sediment retention in the receiving basins, which can be heavily impacted by seasonal growth and decay of plants (see pictures). For instance, river sediment accumulation increases the elevation of seabed, which allows plants to grow in the intertidal zones; accordingly plant growth slows down the flow and damps the energy, allowing more fine-grained sediment to accumulate near the plants. This **positive feedback** between plant and sedimentation can lead to rapid growth of deltas and high sediment retention rates. On the **negative feedback** side, however, when plants die off because of cold weather, consumption by animals, or the flooding due to rising sea levels, sediment becomes unvegetated and erodible; rapid erosion deepens water depth, making it hard for the plant to grow back.

Although the sediment-plant interaction is extremely important to delta growth, the specific mechanisms controlling this interaction have not been fully understood. This interaction is probably one of the major unknown factors in the predictions of many river-diversion models. Relatively very few sediment-plant interaction studies have been performed on the deltaic plains in Louisiana. The drying and wetting of marsh islands during tidal cycles make the deployment of acoustic and optical sensors difficult because the sensors only work under the water. The seasonal vegetation growth and decomposition rates greatly influence the velocity and turbulence on top of marsh islands, leading to rapid changes on *seabed roughness* and *viscosity* of bottom boundary layer; these two are key parameters, but are often over-simplified in hydrodynamic and sediment dynamics models. In this project, Drs. Xu and Rivera-Monroy will collaborate to study **sediment and plant productivity dynamics**

simultaneously. Dr. Xu will serve as the major advisor of a MS student, and Dr. Rivera-Monroy will be the co-advisor. A 3-year research assistantship is requested to hire a MS student who will deploy state-of-the-art instruments in the field in a receiving basin of river diversion. We do not have any conflict of interest regarding any existing or anticipated contractual and/or funding agreements and the receipt of research funding from CPRA under the CSAP program.

APPROACH

Drs. Xu and Rivera-Monroy will be responsible for the mentoring of the student, purchase of equipment, arrangement of field cruises, evaluating the success of the project, and helping the student prepare annual presentations of research findings to CPRA. The student will spend about 3 years working on the project using observational and laboratory approaches. Our proposed study site will be at Mike Island, Wax Lake Delta (WLD) of Louisiana. Multiple instrumented tripods with optical and acoustic sensors (e.g., ADV, ADCP, PC-ADP, ABS and OBS) will be used to collect hydrodynamics and sediment dynamics data in both winter and summer seasons. We hypothesize that the greatest sediment transport occurs in winter season, during which cold fronts are frequent and river sediment discharge is high. This is also the season when winds are energetic and marsh surface is unvegetated and erodible. In summer season, river discharge is low, winds are calm, marshes are vegetated, and storms and hurricanes can happen episodically (but much less frequently than cold fronts). Plant communities in multiple study sites will be functionally (e.g., productivity) and structurally (e.g., density, diversity) characterized to assess their roles in controlling sediment distribution and sedimentation patterns at different temporal and spatial scales. Our study sites represent different stages in the seasonal plant successional trajectories, typical of deltas, allowing a detailed analysis of the interaction between plant density and sediment transport. We will establish long term plots that include the aforementioned optical and acoustic sensors and obtain direct measurement of above- and below-ground biomass and net productivity including carbon allocation and decomposition experiments. These plant attributes will provide information to determine the partition of organic matter contribution to soil formation relative to imported mineral sediments.

SIGNIFICANCE AND DELIVERABLE

Indeed one of the major unknowns to assess the efficiency of river diversion to create wetlands is the quantitative interaction between plant demography and changes in hydrology as related to sediment transport and soil formation. Understanding how vegetation catalyzes sediment deposition and retention are badly needed in ecological models. Although we know that a subtidal elevation is needed to induce plant colonization, it is not clear how plant structure control sediment deposition. Since salinity is a major driver in controlling plant diversity, we need to understand how the interaction between salinity and sediment loads trigger plant development and at what point organic material produced in situ significantly contribute to maintain soil elevation warranting wetland stability. In addition, our in-situ time-series experiments will allow us to evaluate the functional role of plant species that could be used as initial colonizers in planting restoration programs; our results also help the scientists better understand the switches between positive and negative feedbacks.

Deliverables in this project include conference presentations, peer-reviewed journal articles, and sediment transport datasets available to scientific communities. A unique dataset of hydrodynamics, sediment dynamics, ecology and morphology will be collected. These data will be used to investigate the mechanisms controlling the growth of Mike Island of WLD, and the impacts of rivers, storms and plants on sediment accumulation on WLD. Our long-term goal is to provide inputs for (and validate) multiple models used for diversion predictions. For example, our grain size and porosity data can be used to as inputs for the ecosystem model to simulate nitrogen biogeochemistry in wetlands. Moreover, mud content, porosity and organic matter content together can greatly control sediment cohesiveness, which is one of the most important parameters controlling delta morphology in Delft-3D model used by both LSU and The Water Institute of Gulf. Our data will support the formulation and validation of the models that can be parameterized for WLD, and are subsequently transferred for utilization in other future diversion sites. This will directly benefit many projects of coastal protection and restoration in Louisiana.

EXPERTISE

Dr. Xu is a geological oceanographer with extensive research experience of sediment dynamics and his information is at http://www.ocean.lsu.edu/index.php/people/faculty/kehui-xu/;

Dr. Rivera-Monroy is an experienced wetland biogeochemist and his information can be found at http://www.ocean.lsu.edu/index.php/people/faculty/victor-hugo-rivera-monroy/ .